

A VIEW OF GRAVESEND AND TILBURY showing the situation of the PROPOSED TUNNEL.



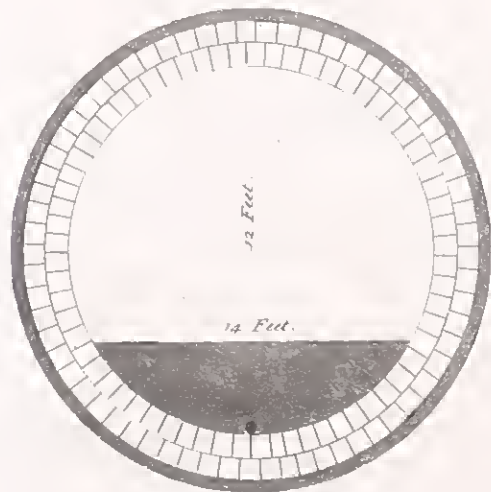
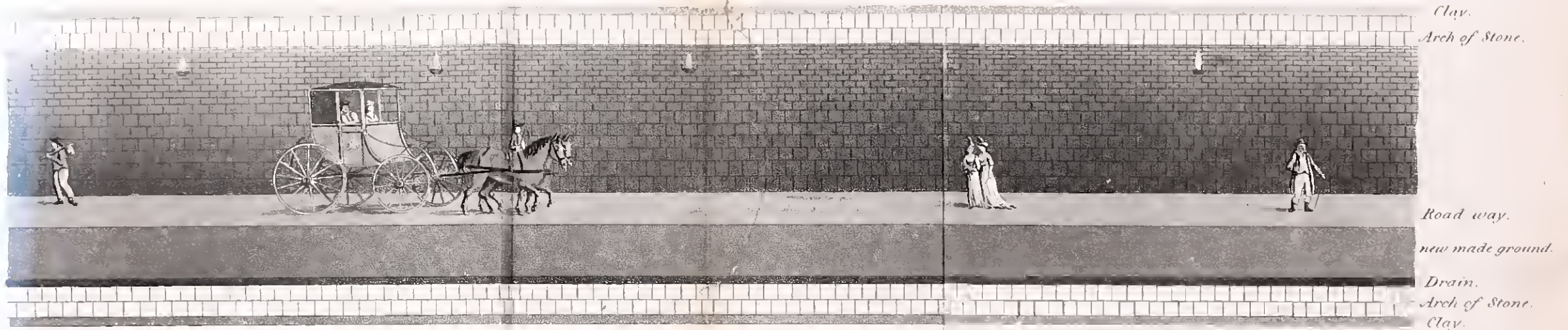
Section of the RIVER in the line of the TUNNEL showing the Strata & the depth of Water in fathoms.



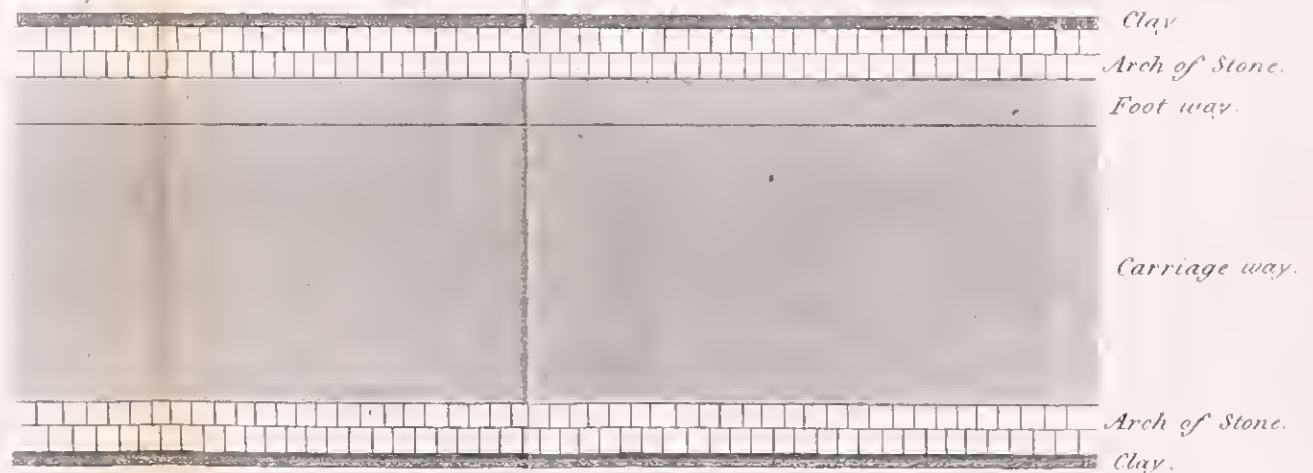
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Horizontal Section.



Vertical Section.



Plan.

Plan & Sections of the proposed TUNNEL from Gravesend to Tilbury.

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Charles Cobham Esq

Dear Sir

We have pleasure

in reporting the following
item which may perhaps
be of interest to you.

(as over)

We Remain

Yours Respectfully
Maggs Bros
H.P.M.

Gravesend. — Reports, with
Plans, sections, &c of the
proposed Dry Tunnel, or
Passage, from Gravesend,
in Kent, to Tilbury, in
Essex also on
a Canal from near
Gravesend to Stour.
with some miscellaneous
& practical observations.

By R. Dodd.

With two plates. "
Plan & sections of Tunnel"
+ View of Gravesend +
Tilbury. 4 to,
new cloth. good copy,
Lond. 1798. 10/6

R E P O R T S,
WITH
PLANS, SECTIONS, &c.
OF THE PROPOSED
DRY TUNNEL, OR PASSAGE,
FROM
GRAVESEND, in KENT, to TILBURY, in ESSEX;
DEMONSTRATING ITS PRACTICABILITY,
AND
GREAT IMPORTANCE TO THE TWO COUNTIES,
AND TO
THE NATION AT LARGE:
ALSO ON A
CANAL FROM NEAR GRAVESEND TO STROUD.
WITH
SOME MISCELLANEOUS AND PRACTICAL OBSERVATIONS.

~~~~~  
By R. DODD, ENGINEER.  
~~~~~

ILLUSTRATED WITH PLATES.

L O N D O N:
PRINTED FOR J. TAYLOR, AT THE ARCHITECTURAL LIBRARY, HIGH HOLBORN.

1798.

P R E F A C E.

HAVING for many years been employed in public surveys of canals, coal-mines, harbours, and other similar works of considerable magnitude, my mind, always active, has long been pondering the thought of the great advantage it would be to commerce, if an easy communication could be effected between certain places where Nature has planted a barrier, apparently insurmountable. The usual mode of doing this by bridges, in many situations, is absolutely impossible; and in many, the expense amounts to nearly the same prohibition.

And although by the late happy adoption of iron bridges, which obviate many of the objections to which bridges of stone or brick are liable, of which a most noble specimen has lately been achieved in the north by an Individual, highly to his honour, and to the advantage of his

country, yet I am unwilling to yield the exertions of art as no further available.

From the importance of a communication between the towns of North and South Shields, which were under my constant view, and where no bridge could possibly be constructed, my mind happily thought upon the scheme of making a subterraneous, and I may say a subaqueous passage, to accomplish this desirable purpose: the idea once conceived, art and science soon accomplished the rest; and I had the honour of making a report under the auspices of that noble patron of arts, the Duke of Northumberland, and other respectable Persons, to the Gentlemen of those towns, on the subject; an outline of which will be found in these sheets. It is hardly necessary to say, not the want of practicability in the plan (for that was never doubted), but other untoward circumstances of our country, which then took place, too obvious to mention, adjourned the completion for a time; I am led to hope not a distant period.

In the course of my professional travelling, I observed the want of a grand uninterrupted line of communication
in

in the fourth-east part of the kingdom, which would easily be obtained, if the river Thames could be conveniently passed. Under this impression, a little reflection and consideration pointed out Gravesend and Tilbury, places already considerably connected by a ferry, as the points where the two counties would with most advantage be united: this datum being adjusted, the rest of the business followed in that succession which I shall lay before my readers in the following sheets; which, with the plans, &c. annexed to the pamphlet, will, I hope, give a clear view of the business, and evince the practicability and great importance of the object.

I am led to make these papers public in a collective form, as the most complete way of answering the many inquiries my Noble Patrons, concerned in this business, and myself, have experienced from persons wishing information on a scheme, interesting to some, on account of its novelty, and to others, on account of its importance.

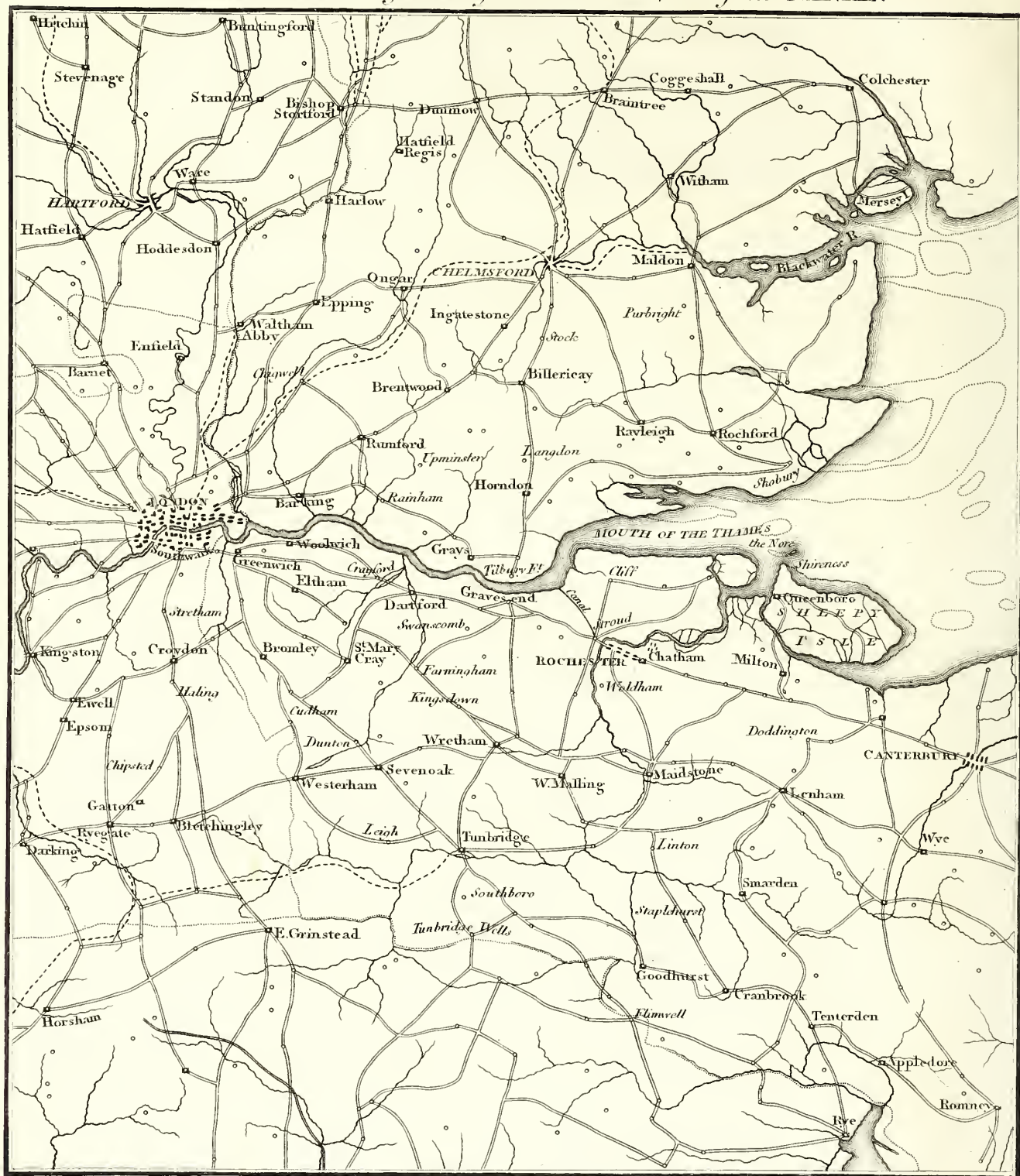
As one link of a chain draws on another, so has the subsequent idea of the canal from near Gravesend to Stroud, of which an account is given at the end of this work, been
drawn

drawn on by the necessary consideration and inspections of the country for the tunnel; and, taken together, I think I may be allowed to say, no proposals of late date abound more with advantages to the neighbouring districts, and to the country at large.

R. DODD.

[Faint, illegible handwritten text, likely bleed-through from the reverse side of the page.]

*A MAP Showing the ROADS and principal TOWNS,
within the immediate Influence of the TUNNEL, and of the CANAL.*



EXPLANATION OF THE PLATES.

PLATE I. *Plan of the Tunnel, with a vertical and horizontal Section.
The Particulars of the Construction are marked on the Plate.*

PLATE II. *View of Gravesend and Tilbury, from the Middle of the
River, showing the relative Situation of the Tunnel to those Towns.*

*The Outline underneath gives an exact Section of the River in the Line of
the Tunnel, with the Depths of Water, and the Soils or Strata, from
actual Soundings and Borings: the Part shaded the darkest, is Clay;
the lighter Part is all Chalk.*

PLATE III. *A Map exhibiting the Country about Twenty Miles round
Gravesend and Tilbury, showing the Roads and principal Towns
within the immediate Influence of the Tunnel, and of the Canal.*

R E P O R T S,

&c. &c.

THE subsequent pages will lay before the public, a measure of considerable local importance, and national improvement—the adopting of dry tunnels under branches of the sea, rivers, &c. as substitutes for bridges, and in such places where bridges are impracticable. I shall confine these observations and remarks principally to my proposed scheme of a tunnel from Gravesend in Kent, to Tilbury in Essex; which, since my ideas on the subject were first published, has considerably occupied the mind of the public, as well for the novelty, as for the importance of the plan. I shall explain the leading features of this subterraneous structure, without attending to elegance of style, or unnecessary ornament; and, avoiding all technical terms, I shall with plainness, and as much brevity as the subject will admit, proceed to communicate my ideas on the important scheme; and probably I cannot do it in a more regular manner, than by giving my first introductory report on the subject, to the Nobility and Gentry of the counties of Kent and Essex.

“ *To the NOBILITY, GENTRY, &c. of ESSEX and KENT.*

“ *My Lords, and Gentlemen,*

“ IN stating my sentiments in this introductory report, it is my intention to use as much brevity as possible, at the same time to omit no essential information; and certainly every projector of public

undertakings of magnitude and utility, should think himself happy to communicate information in the clearest manner possible. To collect sufficient information, and convey instruction, it is necessary, first, with precision to record facts, that will bear investigation, to arrange such materials in a regular system, clear and accurate, from the information obtained in an actual survey—but any collateral matter that draws up or excites a spirit for improvement, is certainly useful: and as many only want information to stimulate them, it would therefore be an omission not fully to convey my ideas as far as can be, previous to an actual survey; and when I mention that the object is no less than uniting the communication of the two great counties of Kent and Essex, by a method, that the hitherto insurmountable barrier the river Thames will not prevent, it must meet with the approbation of all lovers of improvement.

“ The great and much-extended scale of our floating traffic on the river Thames forbids the possibility of a permanent bridge being here constructed over it, from one county to the other; but this projected passage gives no obstruction to the commerce on the river: and notwithstanding however novel the idea may appear to some, it is both practicable, and pregnant with utility. But, as the practice of making passages, tunnels, or drifts under rivers, for the purposes of commerce, is probably unknown to many in this part of the kingdom, it may be proper to mention some places where they are already constructed; viz. at the coal works under the rivers Tyne and Wear; and at Whitehaven, under the very ocean: these excavations are at present occupied with horses and carriages passing with coal, the stream running over head.

“ From an actual survey I made in the early part of this year, it is intended to make a tunnel at the mouth of the river Tyne, near the sea, to answer all the purposes of a bridge, for horse, foot, and carriage passengers, thus giving facility to the land commerce between the two counties of Northumberland and Durham, saving a circuit of 18 miles,

by avoiding the bridge at Newcastle, as well as preventing other numerous inconveniences.

“ The measure now projected, will save the necessity of passing by London bridge, and thereby a circuit of near 50 miles, independent of its giving ample opportunity for various establishments, and agricultural improvement; and I think it would argue an apathy not to be expected in the inhabitants of these two great counties, not to pursue the important benefits to be obtained from this scheme, so reciprocally advantageous to each county: certainly any neglect must call loudly for censure; for where two counties of such magnitude can be joined at so small an expense, it ought not to be omitted, as it will add to their commerce, population, and convenience.

“ Probably the hand of Nature never formed a better situation for this purpose, than at or near Gravesend, on the river Thames, from the eligibility of the shores on both sides the river, and the apparent rock of chalk to pass through. I should recommend the form of this passage or tunnel to be cylindrical, wholly made with key-stones; therefore the greater the pressure the stronger will be the work; having a diameter of 16 feet in the clear, which will be a sufficient width for foot, horse, and carriage passengers; to be illuminated with lamps, and a steam engine to draw its drainage water, if necessary. Upon this scale, I shall give a general estimate from ocular observations.

“ I conceive that 900 yards of tunnelling will be sufficient for passing under the bed of the river, and keeping each of its extremes at a proper distance from the banks; at what depth it must pass under the bed of the river, can only be determined by our borings hereafter, made in an actual survey, to determine its strata, &c. And although mathematical precision is not to be looked for in this preliminary report, I confess myself seriously, and perhaps interestedly impressed with a desire, that this statement may not differ materially from the one that may arise from a more minute survey. Thus influenced, I believe my present esti-

mates may be considered as fully adequate; but for the better information of Gentlemen who wished me to draw up this report, I mention the fact, that some of the most considerable tunnels in this kingdom, on a scale of 19 feet by 17 (which is larger than the one at present recommended), have been executed at 12/. per running yard; therefore the annexed estimate must certainly be thought sufficient in point of expense for executing, as in them I have allowed the most liberal prices usually given in such undertakings.

ESTIMATES, &c. &c.

	£.
To 900 yards running measure of tunnelling, including the excavation and vaulting with key-stones, &c. at 12/. per yard	10,800
To relaying the bottom with new-made ground, 900 running yards, at 1/. per yard	900
To fixing lamps and lamp-irons through the tunnel, toll-collectors' rooms, gates, &c. at each end	400
To making good entrance roads at each end of the tunnel	160
To a steam engine, pipes, &c. if found necessary to draw off the drainage water	1,780
To necessary machinery during the execution	500
To 10 per cent. upon the whole for contingencies	1,455
	£. 15,995

A sum too small, to be brought into contrast with the magnitude and usefulness of the passage or tunnel; for whether we consider it as a great national improvement, or a local one to the two counties, or forming a military pass of the first consequence in this part of the kingdom, for armies, &c. to pass through, its importance claims the greatest attention.

“ What may be the most proper method to raise the supplies for the execution of this grand undertaking; whether it be by the joint expense
of

of both counties, or by the subscription of private individuals, incorporated with liberty from Parliament to levy tolls, is a matter for future consideration; but I am confident the latter would pay ample interest to its share-holders. It is certainly the duty and interest of the state to support this and all other public improvements; and of every individual who admits that agriculture and commerce are objects worthy the pursuit of nations. The preceding observations will suggest to every lover of improvement in the counties of Kent and Essex, that there are pursuits from which they may derive convenience and superior commerce, and that any plan for those improvements is at least worthy of public attention; which I hope my future report from the actual survey, with its accompanying plans, will fully demonstrate.

“ I am,

“ My Lords, and Gentlemen,

“ With great respect,

May, 1798.

“ Your humble servant,

“ R. DODD.”

AFTER the above report had been some time in circulation, it was deemed necessary, to give some solidity to the business, to convene a meeting of the neighbouring Gentry, &c. when the following resolutions were unanimously adopted.

“ *At a MEETING held in the TOWN-HALL of GRAVESEND, on WEDNESDAY, the 18th of JULY 1798, pursuant to an Advertisement in the public Papers;*

“ *The Earl of DARNLEY in the Chair;*

“ MR. DODD having submitted his plans and estimates for constructing a tunnel under the bed of the river Thames, from Gravesend to Tilbury; opening an uninterrupted communication for carriages, &c. between the counties of Kent and Essex; and several letters from gentlemen:

men of Essex (whose attendance at this meeting was prevented by the assizes for that county), approving the measure, and offering their concurrence; and also a letter from the Secretary of the Board of Ordnance, announcing the favourable result of a survey made under the direction of Government, by Colonel Twiss and Capt. Holloway, of the Royal Engineers, having been read;

“RESOLVED, That, in the opinion of this meeting, such a communication would be highly desirable, and of most important national advantage. That seeing no reason to doubt the practicability of the measure, the co-operation of Government, the assent of the land-owners on both sides the river, and (from the offers already made) the willingness of the public to subscribe towards its accomplishment; it is the opinion of this meeting that transferable shares of 100/. each seem to afford the most desirable mode of effecting it.

“RESOLVED, That a book be opened at the office of Messrs. Evans and Son, at Gravesend, where those gentlemen who wish to support and encourage the undertaking, will have an opportunity of entering their names: and that these resolutions, with the plans, estimates, sections, &c. be laid before the Grand Juries of Essex and Kent*.

“Signed at the request of the meeting,

“DARNLEY.”

* It may be necessary to observe the above resolutions were complied with, and I am happy to observe, meet with a most cordial reception; when the Grand Juries, properly considering the importance of the measure, entered jointly into a resolution of holding a meeting in London, for the further consideration, and accelerating the undertaking; at which meeting is intended an invitation for the attendance of a deputation from the Board of Ordnance, the Elder Brethren of the Trinity-house, and the Corporation of Gravesend.

The following is the report referred to in the above resolution, previous to the examination of which, it may be proper, by a due attention to the Plan and Sections, &c. fully to understand the construction proposed.

“ *The REPORT, ESTIMATE, &c. of the projected TUNNEL under the River THAMES, from GRAVESEND in KENT, to TILBURY in ESSEX. By R. DODD, Engineer.*

“ *To the NOBILITY and GENTRY in the Counties of KENT and ESSEX, assembled at a Meeting in the TOWN-HALL, GRAVESEND, KENT.*

“ *My Lords, and Gentlemen,*

“ IN this report from the actual survey, I find no reason for adding to the estimate of expenses given in my former report, but rather an abatement of 3,141*l.* 12*s.* from the sum there estimated, viz. 15,995*l.* which will reduce the original sum to 12,853*l.* 8*s.*; which advantage arises thus: the part I find most eligible to pass through is just above the town, through a chalk rock * of excellent quality; therefore considering the soil so excavated to be worth 2*s.* per yard, cube, which is generally sold at 2*s.* 6*d.* independent of the flints found among it, which usually sell from 10 to 15*s.* per yard, cube, will produce 3,141*l.* 12*s.*; for as it is necessary to excavate 31,416 yards, cube, on the proposed scale of 16 feet clear within the tunnel, the quantity necessary to be cleared away through the rock, will be about 20 feet diameter; its circumference therefore will be 62 feet, 8,320 decimal parts; its length 2,700 feet, or 900 yards; area of the mouth or end, 314 feet, 1,620 decimal parts; the whole to be excavated, in solid feet, 848,232 feet, or 31,416 yards; base area of the stone vaulting, 113 feet, 76 decimal parts, at 2 feet thick; solid feet of the stone-work, 305,120 feet, 5,200 decimal parts; space or vacuum with the vaulting, 543,111 feet, 4,800

* A small portion of the line on the Essex side will pass through a clay soil.

decimal parts; whole external concave surface, 170,274 feet, 7,200 decimal parts. If the dimensions first recommended for the tunnel be reduced from 16 feet to 12 feet diameter, its circumference will be 50 feet, 2,656 decimal parts, and require an excavation of 542,868 feet, 4,800 decimal parts, solid feet; the cost of which will not exceed 10,000*l.* for executing, allowing the amount from the sale of the excavated chalk to be added to it. The deviation from an horizontal line of the tunnel, which passes at about 30 feet below the bed of the river, will be about 4 inches in the yard.

“ The importance of this undertaking embraces two great objects for consideration; first, the uniting for commercial purposes the great east part of this kingdom; secondly, that which at this momentous crisis is of more importance, it will form a military pass of the first consequence in this part of the kingdom; thereby, independent of all other convenience, it would set aside the present necessary military ferry, so unavoidably expensive to the country. The execution of the proposed plan, if set about with spirit and energy, may be completed in twelve months. It is an unpleasant truth, that the barges used for the ferry, when passing troops over the river, &c. stop the navigation, by having taught their hawfers, independent of the length of time the service is in performing. But what is worse, there are times when it is impossible to use them: how inconvenient this to our troops, which may at that crisis want to be passed over either for attack or retreat? Further I am informed, that the persons attending on these barges, cost Government, annually, above 3,000*l.*; the first cost of the barges, mooring-anchors, hawfers, &c. could not be less than 5,000*l.*; add to this their wear and tear, at 200*l.* annually; I believe, upon an impartial inquiry, it will be found there has been more money spent within the last three or four years, in carrying into execution, and maintaining the present system, than would have executed the tunnel; which, when once finished, would require little or no repair for ages, and would be a permanent passage at all periods.

“ From

“ From what I learn, the present ferry, &c. lets for 110*l.* per annum; and for the subsistence of the ferrymen employed, with the wear and tear of boats, &c. it cannot produce less than 900*l.* per annum.

“ If we consider there are few passes the present ferry, but such as are necessitated, and that many, through fear and dislike to the water, prefer a circuit of many miles, who doubtless would make use of this convenience now proposed; I believe, on the adoption of bridges instead of ferries, passengers and tolls generally increase three-fold; and I have known them in a less likely place, than between Gravesend and Tilbury, increase five-fold, which my observation will not admit me to doubt will be the case at this place. Further, another circumstance of great importance, and which must sooner or later take place on the adoption of this plan, and which must greatly increase its tolls, will be the making of a great line of road, so much wanted, to communicate all along the eastern part of the kingdom. The improvements which this tunnel will communicate to the country, in a civil point of view, will be perpetually increasing, from the improvement it would give to agriculture and commerce, by opening of new roads, &c.

“ If a tunnel executed on a plan of 12 feet in the clear, which some persons may think sufficient, should be resolved on (though for my own part I prefer the larger plan), it would admit carriages to pass one way at a time, and might be executed so as not to exceed 10,000*l.*: this scale might be enlarged at any future period, or another of the same dimension might be made on a parallel line with it, and so allow a constant passage each way, reverse to the other: the only additional expense that would occur by having two small tunnels instead of one large one, besides the cost of construction, would be the additional number of lamps, as one steam-engine might draw off the water from both, if troubled with any, which is little to be expected; for this reason, viz. that the whole extent of tunnel will be nearly, if not absolutely, water-tight; the only water then to contend with, will be during the execution, if any should spring up in the face of the working, during

its excavation, which must be from that part within the circle of its diameter; it will be locked up, and made water-tight, every ten or twelve inches, as the work proceeds, and thereby effectually keep the roof from injury. On the completion of the tunnel, it will admit to reduce the tolls charged by the present ferry, at least one third, and yet leave an ample interest for the subscribers, if executed by subscription: but if executed by the two counties, as a matter of general benefit to each, it ought to be toll-free, or at least as soon as it has paid for its execution; or if the tolls were continued on a Sunday, or for late hours, they would pay the necessary expenses of servants, oil burnt in the lamps, &c.; or a sufficient sum might be borrowed, and its interest and principal hereafter be paid by the tolls: but all those observations are for the consideration of you, Gentlemen of the counties.

“ Should my opinion be desired from my previous acquaintance with similar concerns, as to what I thought the best mode, I certainly should recommend dividing the sum necessary to be raised, into one hundred pound shares, payable by instalments; and the shares to be transferable; subscribers to vote on all occasions in proportion to the number of shares they hold; yearly or half-yearly dividends to be made from the toll, to be divided amongst the subscribers; and for the present time, a committee should be immediately formed, with power to add to their number; this committee to take into consideration what has already been done for the furtherance of this undertaking, and what may yet be necessary, previous to application to Parliament for leave to levy tolls, &c. on carriages and passengers passing the tunnel: which measures should be entered into as soon as possible, as the parliamentary forms to be complied with, require notices to be given in the months of August or September previous, for leave to bring in a Bill.

“ I am,

“ My Lords, and Gentlemen,

“ Your very humble servant,

“ R. DODD.”

The

The map will show the circumjacent country and roads in connexion with the tunnel. I wish it by no means to be understood, the benefits of this plan will extend no further than the boundaries of my map ; but enough is here given, to show the important connexion it has with the commerce, agriculture, and military affairs of these districts.

From what has been already said, I presume it is sufficiently well understood, the form of this passage or tunnel is, as it were, a tube of about 900 yards long, and of 16 feet interior diameter ; the bottom of which being refoiled or filled in 4 feet, will leave a height of 12 feet ; and the width will be on the carriage-way nearly 16 feet (see the vertical section on the plate). The whole to be lighted by lamps, burning constantly, or at all needful times.

I beg leave here to say a few words, by way of comparison, on the several advantages of dry tunnels over bridges of iron : tunnels, I am well persuaded, will last five times as long as an iron bridge, and without any expense for repairs ; they are not subject to the decay of rust, nor to injuries arising from the expansions and contractions of heat and cold ; and above all, the first cost will not be the fourth part of an iron bridge. When considered as a military road, how easy is the destruction of an iron bridge, from the brittleness of the materials ? a few well-directed shot would, I fear, soon destroy the fabric. It is true, the tunnel is liable to the action of the miner's art : so equally is a bridge ; but a few men may effectually defend the former.

These warlike observations may, by some, be considered as foreign to my subject ; but had they seen some places in America, and others on the continent, which I have seen, they would have had sufficient demonstration of the great utility of tunnels for passing rivers, in preference to bridges, when armies are contending with each other. And although no man hopes more sincerely than I do, this will never be the case in happy Old England, yet certainly it is well to have these thoughts

in view, and wise to provide against the worst; and of this opinion I have to observe are some of our most distinguished military characters.

I shall now proceed to give some general remarks respecting the practicability and execution of this novel and interesting scheme. The length of the line is 900 yards, which will pass from about 20 to 30 feet below the bed of the river; the depth of water in the deepest parts above the tunnel, is 11 fathom, or 66 feet, in the highest equinox spring tides (see the section of the river, under the general view, where the measurements and stratas are laid down from actual borings and soundings); therefore the crown of the arch may be considered as not exceeding 96 feet, from the summit water-line, which will produce an inclination from an horizontal line of nearly 4 inches in a yard. The tunnel may be constructed either of stone or brick; the lower segment of which will of course be the first executed, and the upper one from centres of a proper figure; the whole wrought in terrace, and sufficiently bedded in clay, to admit no water; and for greater security, we proceed with a small part at a time, that we may not too much disturb the strata in working. When the entire circle is completed by the workmen, it will be of a strength superior to the original bed of chalk we pass through: from the actual borings made to determine the strata, I find we have to pass nearly the whole way through chalk; but some small portion of the way, on the Essex side, through an excellent clay (see the section), mixed in some places with a portion of petrified vegetable substances, covered over, beyond high-water-mark, with a few feet of rich loamy mould; but on the Kentish shore, a solid chalk rock presents itself to the surface.

It has been observed, that, should we be troubled with water during the execution, a steam-engine may be erected sufficient to prevent the works being impeded.

As many excavations in the earth are troubled not only with water, but with fire (usually termed inflammable air), the necessary measures will

will be adopted to prevent its baneful effects, as well as from styth or black-damp ; and I shall here say a word or two on the subject.

The following practical remarks are necessary to be attended to for the discovery of inflammable air, or fire-damp, which sometimes arises in mines and subterraneous passages, when not properly ventilated. On entering any excavation under ground, where this fire-damp is suspected to lie, the candle ought to be held in the left hand (the smaller the candle the more to be depended upon), and the flame thereof to be shaded by the right hand fingers, being placed horizontal, and on a level with the top of the flame of the candle : if the air be good, and perfectly free from any inflammable air or hydrogen, a small brown top or pinnacle is seen on the top of the flame, the same as is seen in the chamber of a house ; but on approaching the real fire-damp, another top or spire is seen of a blue colour, above the brown, just described, as arising therefrom ; and on advancing a step or two forward, the damp is commonly more dense, and consequently the appearances over the candle assume a more serious aspect, by the brown spire, or small top, beginning to disappear ; another step perhaps reduces it altogether, on which the danger commences ; and the spire or top sits down altogether blue on the flame. At this last stage it is not safe to proceed further without great circumspection, joined with steadiness : a little further, the blue top is seen to be more perfect and dense, which if general throughout the place, all lights should be extinguished, and the workmen be made to quit the place : perhaps on advancing a very little further, a light blue bead appears to circumscribe the other dark blue, as if approaching to flame, and having a more than ordinary pointed spire, terminating like a white thread ; and the danger becomes very great, if to remain any time in this position. The next stage shows the sprents to have taken place, which sprents are similar to those produced by squeezing the oil from the rind of a lemon into the flame of a candle ; at this period sometimes has been observed a small bushy dark-coloured cloud hanging over the top of the flame, still more and more attracting the fire, when in an instant perhaps after this last observation, the whole appearance expands
into

into flames, and one general conflagration takes place. The mischief which ensues, is in proportion to the accumulated quantity of this pernicious vapour, which, if great, flies to the nearest aperture leading to the atmosphere, being about eleven times lighter than common air, with a dreadful explosion, and extraordinary eruption. But in case the said fire-damp, or inflammable air, be mixed with styth, or black-damp, these appearances are somewhat varied; and by being mixed with a very dark brown, is in general more safe.

Black-damp, or styth, which arises in mines, is directly the reverse of inflammable air, or fire-damp; the former extinguishes the flame of a candle as quickly as if put into water, or any other fluid; the other causes the candle to burn too fast. This styth, or black-damp, prevails most where there is little or no inflammable air, and when the due circulation of atmospheric air is neglected.

But, in case we should be troubled with any of those vapours during the excavation, they will be effectually dispersed by means of a *brattish*, as termed by the coal-miners in the northern counties, by the assistance of which, and material fire, pure atmospheric air may be conveyed for many miles underground. Brattishes are nothing more than tubes of various sizes and figures, by which means, the atmospheric air is brought into mines for cleansing them from all fulminating vapours.

But it may be necessary to observe, on the completion of the tunnel, there will always be a current of pure atmospheric air passing through it, without the aid of any machinery; as experience teaches us, that air, like water, rushes most in confined passages, which will further be much aided by the burning of the lamps in the tunnel.

It is worth while here to remark the grand utility of this tunnel, by opening extensive roads in the counties of Norfolk, Suffolk, Essex, Kent, and Suffex; and that its extremities are near to the points of the great leading north and south roads of Kent and Essex. This communication,

nication, when once completed, will be superior to any bridge, as from its strength and durability it would require little repair for ages. As to the practicability of its execution, it cannot admit a doubt, if we adopt the old adage, that what has been done, may be done again. I have already mentioned that excavations or passages are made under the sea at Whitehaven for upwards of one mile in length; and on a much larger scale than necessary for this proposed tunnel; add to these, those passing under the rivers Wear and Tyne, as adopted by the coal-miners for the purpose of passing coal from one side of the river to the other. Necessity gave rise to these inventions, from the cause of working out the coal on one side, and then driving a tunnel or drift to the other; by which means, they obtained coal from the opposite side, without being at the expense of making shafts for raising it. The first circumstance that I recollect of this nature, took place at Wylam colliery, on the river Tyne, some years ago; since which period the whole of the coal has been wrought on the south side, and passed through a tunnel under the river, and brought up the shaft to bank on the north side*. Within these few months, the extensive colliery of Walkers, so well known for the superior quality of coal it sends to the London market, has adopted a similar measure.

The earliest tunnel that we have account of for the purpose of inland navigation, was executed by that able engineer, Mons. Riquet, to con-

* In the year 1795, when surveying the canal navigation I had the honour of projecting across the island from the east to the west sea, by way of Newcastle and Carlisle, I was shown an air shaft on the south side of the river belonging to Wylam colliery, 32 fathom, or 192 feet deep; from the top to the bottom of which a cow fell that was grazing near its mouth, and, wonderful to relate! received little or no injury; from this cause I suppose, its hinder parts, as possessing most gravity, went first, and its horns alternately caught on the rough and jagged parts of the shaft, which friction could only prevent its velocity in falling. The horned animal, on being first discovered, created no small surprise amongst the pitmen; it was immediately drove through the above described drift or tunnel under the river, to the bottom of the shaft on the north side, put into the net used for the passing up and down of the pit horses, hoisted to bank, day, or pit heap (as termed). The poor animal, when loosed from the net, saw its accustomed place of abode on the opposite shore, ran to the river side, and immediately swam over to its own home.

vey the canal of Languedoc through a mountain near Beziers. It is cut into a lofty arcade, and the greatest part of the way lined with free-stone, except towards the ends, where it is only hewn through the rock, which is of a soft sulphurous substance.

The first executed in this country was by the ingenious Mr. Brindley, on his Grace the Duke of Bridgewater's navigation near Manchester: the next noticed is the justly celebrated tunnel of Harecastle Hill in Staffordshire, executed also by Mr. Brindley; its length is 2,880 yards, and passes more than 70 yards below the surface of the earth; it is carried through a variety of strata, quicksands, &c. The above tunnel was executed to pass a canal through it, from the Trent to the Mersey, called the Grand Trunk Canal.

The tunnel of Saperton was carried through two miles of solid rock; its extreme length is two miles and three quarters; it was executed for the purpose of conveying an inland navigation through it, and thereby unite the river Thames and the Severn. Many other tunnels have since been executed in this country; and some are now doing with equal success for the purpose of inland navigation. The great drift or tunnel, about four miles above Newcastle, from the banks of the river Tyne to near Kenton, which was finished last year, is three miles and a quarter in length, great part of which was, with very great labour, perforated through a hard rock of whin-stone, nearly equal in density to the hardest flint; it is made for the express purpose of passing waggons laden with coal: notwithstanding the almost impenetrable strata, and the magnitude of the work, the whole was executed in about four years, and at less expense than persons unacquainted with such works can conceive.

As every information respecting similar concerns must be acceptable to the inquisitive reader, I beg leave here to introduce part of my report on a plan of a like nature, intended to be executed at the mouth of the river Tyne, near the sea.

A RE-

“ *A REPORT and ESTIMATE, on the projected DRY TUNNEL, or SUBTERRANEOUS PASSAGE, under the River TYNE, to communicate with the Towns of NORTH and SOUTH SHIELDS; thus opening a Military Road, or Pass, in the East Part of the Counties of DURHAM and NORTHUMBERLAND. By R. DODD, Engineer.*

“ *To the NOBILITY, GENTRY, LANDHOLDERS, &c. of the East Part of the Counties of DURHAM and NORTHUMBERLAND.*

“ AS the inhabitants of North and South Shields, from their local situation, are so materially interested in the business proposed, I wish them to consider the greater part of this report as addressed to them. They must remember, that in my late survey and report on their harbour in the year 1796, for the improvement of its navigation, amongst other projected improvements for the town and harbour, I mentioned this dry tunnel, or subterraneous passage, under the river Tyne, from one town to the other; and therein, as an evidence of its practicability, referred to some of our own local examples, the collieries on this river working in subterraneous passages from one side to the other. I might also have mentioned the collieries of Whitehaven, working under the very ocean; and for a similar work in appearance, to what this will be when finished, the Adelphi in the metropolis presents us with a grand specimen of its subterraneous passage, or tunnel, from near the Strand, under the whole of those superb buildings, to the banks of the Thames. Here may be found foot and horse passengers, with carriages of every description, passing with the greatest facility by lamp light at noon-day.

“ As its practicability cannot be doubted, I shall consider its expediency, utility, expense, execution, &c. To consider it first as a grand national improvement, it must meet the approbation of every one, that allows this truth, that we cannot have too many communications from one side of our rivers to the other, when they do not obstruct
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navigation,

navigation, which most bridges in some measure do; but this method totally avoids all obstruction: if considered in a military point of view, it will form one of the most important passes in the kingdom; its situation at the mouth of the great river Tyne, taking its entrance within a few yards of the embrasures of Clifford's Fort, on the north shore, and ending under the command of the opposite battery, on the south shore; its length of line only 400 yards, with little incline of plain descending or ascending: through here might pass marching armies of any number, for the protection of either county, with the heaviest train of artillery.

“ I think little dependence is to be made in passing an army on a bridge of boats, or other vessels, in this part of the river Tyne, at some seasons; as experience a few days since has shown, that the freshes, with a descending ebb tide, have torn large merchant-ships, and even men of war, out of the harbour: therefore, if ever there was a time when government should patronise a work of this kind, it is at this period, when a determined and inveterate enemy is threatening us with an invasion: and that this part of the island ought to have a peculiar attention paid to its protection, I could advance many proofs, but shall wave them, as they may be thought foreign to the subject; and shall only observe, that, as this east part of the two counties is most vulnerable, this tunnel will make its defence infinitely more secure, by affording so easy a communication between the two counties, to that part where we have the most reason to expect an hostile enemy.

“ Great will be its utility in laying open the great east part of those two counties, for their improvement in agriculture and commerce, as it will certainly tend much to shorten the line of communication, both north and south, along this northern part of the kingdom; and, as such, add value to its lands, increase its population, and give more energy to its commerce. It must be acknowledged that the want of its accomplishment is most seriously felt by the inhabitants of North and South Shields, wanting the passing of carriages, or cattle, from one

town to the other, which, in bad weather and strong tides, is only to be obtained by passing the first bridge (forming a circuit of 18 miles), which might here be accomplished in 400 yards. Equally inconvenient is it to the foot passengers to pass in rapid tides, and during the stormy months of winter, not to mention the dreadful danger in passing in the night; and as those evils can be averted with little expense to the public (or rather with profit to the undertakers), it should be the desire of every one wishing well to the public weal, to countenance so laudable an undertaking.

“ I am well aware that many will say government ought to execute it; as it will form a military pass, and be so convenient for their armies. I think otherwise; as, by the same line of reasoning, they might build all the bridges, and make all the roads in the kingdom. Others may say—Then it is doubtless the interest of the landholders to execute it, as it will be a mean of advancing the value of their property. It is certainly their duty and interest to lend their assistance, to which they cannot have a greater stimulative than seeing the inhabitants come forward with their subscriptions; for it must be remembered, that Gentlemen who are not residents, will form their ideas of its utility from the countenance it meets with amongst those who are. But many will say, from the pressure of the times, this is no period to lay out money on public improvements; but let them remember that the wise husbandman, when the rentals of his lands are raised to him, lays out more money to improve his farm, which enables him to pay the additional burden. It therefore behoves us, as a wise and discerning nation, to improve our own country and commerce, that we may with ability and cheerfulness bear the absolutely necessary burdens laid upon us.

“ But I think it will require little investigation to show that the execution of this tunnel will be no burden, but a profit to its executors; as such I shall now give the estimates of the expense, presumed revenue, &c. but shall first name its dimensions, figure, &c. It will be observed I before named near Clifford's Fort on the north shore, to

be the best place for its commencement, and terminating near the battery on the south shore; which is certainly to be preferred for two special reasons: first, that from its situation it becomes a military pass of the first consequence in this kingdom; the next, that when nautical sensibility has any share in the conservatorship of the river Tyne, a pier will be erected from near Clifford's Fort, to the rocks fronting the Spanish Battery, according to the plans I have laid down for the improvement of this harbour. Of the want of this pier, the two towns of Shields have lately had a melancholy demonstration—eight ships at once upon the Herd Sands, some beaten to pieces, with the loss of lives from others; and since that period, others drove on the north rocks, or Black Middings, to the greater part of which I have been an eye-witness, and am firmly of opinion that a north pier would have prevented the whole loss of lives and property thus thrown away.

“ The erection of this pier will obtain 60 acres of ground from the sea, and when levelled behind with new-made ground, will produce one of the best situations for a new town imaginable; in which case, the north entrance of the tunnel would be in the mid-way between the two towns. But what is probably more interesting—there is no part of the harbour so narrow, or presents itself with so good a stratum of clay*, beneath the bed of the river to pass through, as the adjoining stratification of the country gives us every encouragement to proceed from this place with the greatest certainty of success.

“ The dimensions of the tunnel, according to the plans I have laid down: I propose a perfect circle of 14 feet diameter, and to pass 20 feet below the bed of the river, and 40 under the water, producing an inclined plane of only 4 inches in the yard, to be formed entirely of key-stones; therefore the greater the pressure the more secure. The lower part of the circle to be filled up with new-made ground, and paved to the height of 4 feet, which will leave the height of 10 feet, with a sufficiency of 3 feet

* From the actual borings I found the stratum to consist of excellent strong blue clay.

on each side for a foot-way, with 7 feet for horse and carriage way, and passing-places at certain intervals. But the whole scale might be made larger if thought advisable.

“ In my estimates I shall allow the most liberal prices, as it is always more agreeable to have a surplus left, than a sum to advance at the finishing of any public work. On these terms, and including all contingencies, the total sum requisite is only 6,983/.—a sum to be provided for, so small, that when it is considered as a measure pregnant with utility to society, it is astonishing any one can hesitate at it, as the harbour and its navigation will admit of no permanent or convenient bridge being passed over it.

“ It now remains for us to consider the best modes to raise the supplies for its execution, with its presumed revenue, &c. After a conversation with some of the gentlemen wishing me to draw up this report, it was thought most advisable to divide the sum necessary to be raised, into shares similar to that of an inland navigation, and to reduce them so low as 25/. per share, to be paid only as wanted, or in four different instalments, with sufficient notice of each payment; so that it might come within the ability of every man in trade, as they are so much interested, to give some assistance; and that a holder of four shares be qualified to serve on all committees, and to vote in proportion to his number—that is, for every four shares one vote; and that the representative of four single shareholders have the same privilege—that shares be made transferable, and that all public transactions be determined by open ballot of the subscribers only.

“ It is now necessary to consider its presumed revenue to pay ample interest to the subscribers. The best mode we can form our judgment on, is, I conceive, of some similar concern: as such, we will refer to that noble work lately executed across a neighbouring river; I allude to *Wearmouth bridge*, the tolls of which since finished have let for 1400/.
per

per annum*. But upon the execution of this projected measure, its tolls will certainly much increafe. Many may think we have no right to expect fuch a revenue at this place ; I think we have, and my reasons are founded on this truth, that where there is most population, there would be most passing of individuals, cattle, and carriages. And that the two towns of North and South Shields, with the neighbouring villages of Westoe, Preston, Monk-Seaton, Whitley, Hartley, and Tyne-mouth, contain more inhabitants than the towns of Sunderland and Monk-Wearmouth, with their surrounding inhabitants, is beyond dispute. But in fact, only half its revenue would be perfectly adequate to pay excellent interest to the subscribers, even after allowing a sufficient deduction for lamp-lighting and toll-collectors. As to the expense of keeping a steam-engine for drawing the drainage water, if there should be any occasion for it, which is uncertain, no expense whatever will attend it, but a saving, as I propose her to lift the water higher than the necessary level, as the means of driving fundry pairs of mill-stones with it ; in which case her rentals will pay good interest for the erection.

“ I am, Gentlemen,

“ With great respect,

“ Your humble servant,

February, 1798.

“ R. DODD.”

* Previous to the erection of this bridge the ferry only let for 180*l.* per annum.

ADDITIONAL IMPROVEMENT.

AS the inhabitants of Kent are so materially interested in the accomplishment of the tunnel at Gravesend, it will no doubt be acceptable to them to hear of other improvements the county of Kent is capable of receiving; as such, I have annexed the following report, with a few observations from a late survey.

The line of the *Canal* is laid down in the map, which also shows the surrounding country connected therewith.

“ The INTRODUCTORY REPORT to the GENTLEMEN LANDHOLDERS, and the commercially interested Part of KENT, near STROUD, ROCHESTER, CHATHAM, MAIDSTONE, TUNBRIDGE, and other Places interested in the projected CANAL NAVIGATION, from near GRAVESEND, on the River THAMES, to near STROUD, on the River MEDWAY; thus forming a Junction of the two Rivers for the Purpose of accelerating Commerce, by avoiding the Necessity of passing the circuitous Passage round the NORE, &c.

“ GENTLEMEN,

“ AS the very existence of our country centres upon commerce, any project that can be brought forward to give the least facility to that spring of wealth and national prosperity, is of the highest importance to the community at large; and that canals have been one great leading cause to our present extensive trade, is a truth which cannot be controverted.

“ If

“ If we look to their local improvements of the country, we find they have made small villages like populous cities; and in some places planted extensive towns and manufactories, that without their aid would never have existed, and thus given employment to the numerous poor.

“ As to their agricultural improvements, from their draining some lands, and their introduction of cheap manure to others, they have perfectly changed the face of the country through which they have passed. This should teach us, as a wise people, to pay every attention to those certain sources of wealth and national prosperity; and it is happy for us in the present day, we have not to search Holland and other places in and out of Europe for a demonstration of their utility, as was the case little more than half a century past; for we now possess them in many parts of this island with all their splendid usefulness. Why the introduction of them to this part of the country should be deferred to this period, is probably a question for future consideration; but it may be necessary in the present instance to observe the cause of this partial investigation.

“ On exploring this part of the county with a view to its improvement, the present object struck me as one of the first advantages the county was capable of receiving. After communicating my ideas to a Nobleman to whom the county is much indebted for his patronage to a considerable public work of national and local improvement to the counties of Kent and Essex (I lately had the honour to submit to the public), from his encouragement, this ocular canal survey was immediately entered upon, a few remarks from which may be acceptable to the interested reader. First then I find the line of projected navigation will be about 6 miles to form the grand junction of the two rivers, through as fine a stratum as can well be wished for: the lower levels will need no puddling, the upper line of chalk will pay for its own excavation; and how far it may be advisable to pass from one river to the other on a dead level, without locks, is a matter that can only be determined by an hereafter actual survey, as well as the expense of its execution,

cution, &c. From the general observations I have made, I see no particular impediment, but every thing is remarkably inviting to form an excellent navigation that will be of the greatest utility to the county at large.—Upon inquiry, I find the commerce that would employ this canal is immense; probably few canals in this kingdom would have greater traffic; from this cause: its short line of about 6 miles would save the usual route of about 47 miles, when passing to any part of the Thames above Gravesend, from the Medway; with the general certainty of vessels passing from Rochester to London in one tide, as from London to thence in a similar period; whereas instances can be proved of many weeks detention during the stormy months of winter, exclusive of all hazards in the usual route of passing by way of the Nore. How far an extensive part of the county of Kent is interested in this canal navigation is for their consideration. These hasty remarks are confessedly only thrown together to stimulate them to those improvements which have rendered other parts of this kingdom the most essential service, as they have added to the wealth of individuals, and improved agriculture and commerce. Should any suggestion of mine have the least tendency to add to the improvement in this part of the county, I must confess it will be one pleasure of life to consider myself the author.

“ I am, Gentlemen,

“ With the greatest respect,

“ Your humble servant,

Gravesend,

“ R. DODD.”

August 10, 1798.

AS the actual survey is not yet completed, it would be improper to enter largely upon this projected navigation; but a few further observations may be acceptable to those commercially concerned; its utility must be evident to the eye of the most superficial observer; but the commercial man only can judge of its grand utility for accelerating the

commerce in that great and extensive part of Kent, termed the Wealds, as well as the northern part of the county of Sussex, independent of its utility to every part bordering on the river Medway. There is probably no navigation in this kingdom, from which government will receive more local advantage, than by a shortened intercourse between the dock-yards of Chatham and Deptford, as also the relative connexion between the Victualling-office at Deptford, Woolwich warren, and the river Medway; for this navigation would give a certain and uninterrupted intercourse at all periods, without the necessity of passing round by the Nore, which, in adverse winds and bad weather, is impracticable.

Since the year 1781, the town of Hull has found the most valuable advantages arise from the canals it has encouraged, to communicate with the river Humber, on which it is situated. The commissioners of accounts for the custom-house paid into the exchequer that year the nett sum of 104,393*l.* which gradually increased to the year 1784, when it amounted to 143,467*l.*; and in the year 1791, to 171,000*l.*; and in the ensuing year upwards of 200,000*l.*; which is a sufficient proof of the great utility of inland navigation. Further, did they possess only this advantage of one horse being able with ease to draw on a canal the load of 30 on the usual road, they would be worth encouragement, from their ridding the country of keeping so unnecessary a number of horses. But as men derive considerable benefit from their intercourse with each other, by their desires equally to communicate and receive advantages from men, whose dispositions and pursuits are congenial with their own; so it is with canals when they form junctions with rivers for trade or commerce, as they become mutually advantageous to each other. Does one country want the production of others for the purpose of manufacture? Canals cheaply supply them, which expensive land carriage would lay a prohibition on; and, if bad roads make a kind of sterility in a country, by leaving extensive lands uncultivated, and markets badly supplied, it must be remembered canals do it readily and cheaply, and thereby prevent monopoly, independent of their being the cause of extensive cultivation,

Are we a maritime nation? On these still waters men learn the first rudiments for fitting them for the more boisterous ocean, by the knowledge of the sail, oar, and rudder; and certainly whatever tends to the nursery of our seamen—those brave defenders of our island, deserves to be particularly attended to.

I shall conclude these remarks with a reflection or two. I am well aware that many persons possess an anxious wish for the accomplishment of this navigation, with the other public works which I have had the honour of projecting for this part of the kingdom, and although well convinced of their general utility, may, from the distress of war hanging on us, entertain faint ideas of their being fully accomplished. I agree with them that war is, and ever has been, the enemy of art; but as these public improvements will better enable the country to defray the expense of it, from the enlargement of its trade and commerce, the sooner they are executed the better, as they are measures so pregnant with blessings to society:—and if they cannot be wholly accomplished now, certainly there is wisdom in preparing these considerable works for happier days.

It may be also necessary to observe, that the preparation for the execution of a canal is not like the beginning of other public works. The wisdom of Parliament has prescribed certain measures to be attended to, which, with the necessary time spent in a well-digested actual survey, consumes a good deal of time, previous to any thing being essentially entered upon. And, besides, supposing there were no possibility of their being immediately put in execution, is it not a national policy to prepare such considerable works ready to employ a disbanded army and navy, which may prevent many of them from emigrating to other countries, or, through want, commit depredations on individuals, and so come to an untimely end? A neighbouring nation, with whom we are contending, adopted that wise measure in the year 1666, for the execution of the great canal of Languedoc, otherwise called the canal of the Two Seas, from its joining the Mediterranean with the Atlantic Ocean,

Ocean, at the distance of 250 miles. It was first projected in the reign of that patron of arts, Francis the First, but begun and finished under Louis the Fourteenth; and that the French have this present war projected similar schemes, the edicts of the National Assembly have publicly announced.

It may not be an unuseful reflection for us to consider, that the very spirit and energy of our present trade at foreign markets is maintained by the excellence of our manufactured goods, from the improved state of our machinery; and, as the execution of those different articles, which are, from the situation of water-mills and cheapness, generally carried on in inland towns, which have communications by canals to navigable rivers, thereby diminishing the expense of carriage, and putting those remote parts of the country more upon a level with our seaports. A sufficient demonstration of what those improvements have done for the trade of this country may be drawn from the imports and exports of the metropolis itself. The imports of London in 1700, were valued at 4,785,538*l.*—the exports the same year 5,387,787*l.*; but in the year 1792, the imports were 12,072,674*l.*—and the exports 14,742,310*l.*

If properly considered, it will be found that all canal navigations executed from the joint stock of individuals are effected merely by the transfer of property, from those who can well spare it, into the hands of those who are necessitated to labour for it, who again expend it in the line of country through which the navigation passes, and that they virtually draw no money from the country but when completed, become estates of immense value to individuals, as well as a general accommodation to the commerce of the nation at large.

